Determining an Empirical Formula

Text

Pre-Lab Discussion

In a sample of a compound, regardless of the size of the sample, the number of moles of one element in the sample divided by the number of moles of another element in the sample will form a small whole-number ratio. These small whole-number ratios can be used to determine the subscripts in the empirical formula of the compound. For example suppose that in a 24-gram sample of a compound, there are 1.5 moles of carbon (18 g of carbon) and 6 moles of hydrogen (6 g of hydrogen). These numbers form the small whole-number ratio of 1 to 4:

$$\frac{1.5 \text{ moles carbon}}{6 \text{ moles hydrogen}} = \frac{1}{4}$$

The 1-to-4 ratio means that for every 1 atom of carbon in the compound, there are 4 atoms of hydrogen. The empirical formula of the compound is CH_4. (The compound's name is methane.)

In this experiment, the number of moles of each of two elements in a binary compound will be experimentally determined. From this information, the empirical formula of the compound will be determined.

This experiment will help you understand better the concepts of moles, masses and empirical formulas.

Purpose

Using mass relationships, show that magnesium and oxygen combine in a definite whole-number ratio by mass.

Equipment

crucible and cover
ring stand
iron ring
clay triangle
crucible tongs
dropper pipet
scissors
burner
balance
safety goggles
lab apron or coat

Materials

magnesium ribbon (Mg), 35cm

Safety

Do not touch a hot crucible with your fingers, and be sure you use tongs to shift the position of the hot crucible cover in step 3. Use a hand to waft the gas given off in step 6 to your nose. Avoid directly inhaling reaction product gases. Do not place any magnesium ribbon in an open flame.

Observe the caution alert symbols under "Procedure," and follow the precautions indicated. Tie back long hair and secure loose clothing when working with an open flame. Always wear safety goggles and a lab apron or coat when working in the lab.

Procedure

1. Clean a crucible and cover. Dry them by heating them in the hottest part of a burner flame for 3 minutes. Allow them to cool. Measure the mass of just the crucible and record this as (a) under "Observations and Data."
2. Cut a 35-cm length of magnesium ribbon into 1-cm pieces. Place the pieces in the crucible and measure the mass of the crucible and its contents (b).
3. Cover the crucible and place it in a clay triangle (Figure *13-1*). Heat *gently* for 2 minutes. Using crucible tongs, carefully tilt the cover to provide an opening for air to enter the crucible. Heat the partially covered crucible *strongly* for 10 minutes.

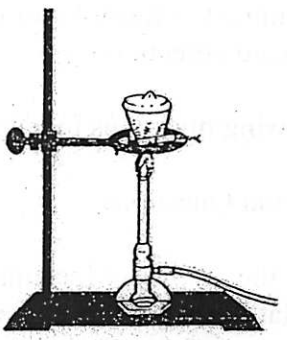

Figure 13-1

4. Turn off the burner, cover the crucible, and allow the contents to cool. When the crucible is cool enough to touch, remove the cover and examine the contents. If any unreacted magnesium remains, replace the cover at a slight tilt, and reheat the crucible strongly for several minutes.
5. Put the cover all the way on and allow to cool. After making sure that all the magnesium has reacted, use a dropper pipet to add enough water to the crucible to just cover the contents. Wash any material that may have spattered onto the inside of the cover into the crucible.
6. Holding the burner in your hand, *gently* heat the contents of the uncovered crucible by moving the burner slowly back and forth. Avoid spattering. Observe the odor of the vapor given off by wafting it toward your nose. Record your observation as (d).
7. When all the liquid has boiled off, repeat steps 5 and 6.
8. When all the liquid has boiled off a second time, *strongly* heat the uncovered crucible for 5 minutes.
9. Turn off the burner and allow the crucible and contents to cool. Measure the combined mass of the crucible + contents (c).

↳ after you repeat 5+6 measure to constant mass.

Place all the collected data and calculated data in the appropriate tables.

Calculations

1. Find the mass of the magnesium that was used.
2. Find the mass of the oxygen that reacted.
3. Find the number of moles of magnesium used
4. Find the number of moles of oxygen that reacted.
5. Find the ratio of magnesium to oxygen in both moles and grams.
6. Determine the formula for oxide of magnesium
7. Calculate percent error.

Use the following questions to help for discussion points in your lab write ups.

Conclusions and Questions

1. Write the empirical formula of the oxide of magnesium based on your calculations from this experiment.
2. What is the ratio of the mass in grams of magnesium used to the mass in grams of oxygen that reacted? Relate this mass to the law of definite composition.
3. Why is the ratio found in question 2 different from the molar ratio?
4. In a chemical formula, explain the significance of subscripts in terms of atoms, molecules, and moles.
5. What is the empirical formula for hydrogen peroxide?
6. How is the chemical composition of carbon monoxide similar to carbon dioxide? How is it different?
7. A sample of sulfur having a mass of 1.28 g combines with oxygen to form a compound with a mass of 3.20 g. What is the empirical formula for the compound?